

## TITLE OF THE INVENTION

TRANSPARENT CONDUCTIVE LAYERED STRUCTURE AND

METHOD OF PRODUCING THE SAME, AND

5 TRANSPARENT COAT LAYER FORMING COATING LIQUID

USED IN THE METHOD OF PRODUCING THE SAME, AND

DISPLAY DEVICE TO WHICH

TRANSPARENT CONDUCTIVE LAYERED STRUCTURE IS APPLIED

## 10 BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a transparent  
15 conductive layered structure comprising a transparent  
substrate and a transparent two-layered film being composed  
of a transparent conductive layer and a transparent coat  
layer being formed in succession on the transparent  
substrate, which is used in front panels, etc., of display  
20 devices such as Braun tubes (CRTs), plasma display panels  
(PDPs), vacuum fluorescent display (VFDs), liquid crystal  
displays (LCDs). The present invention particularly  
relates to a transparent conductive layered structure  
having the functions of preventing electrostatic charging

or shielding an electric field, and preventing reflection,  
the two-layered film of which has an excellent scratch  
strength, and with which a reduction in production cost is  
expected and a method of producing the same, and a  
5 transparent coat layer forming coating liquid used in the  
method of producing the same, and a display device to which  
the transparent conductive layered structure is applied.

## 2. Description of the Related Art

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Many OA devices have been introduced to the office  
as a result of office automation (OA) in recent years and  
an environment in which the entire day work must be done  
facing the display of OA device is no longer uncommon.

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However, when a job is done next to a cathode ray  
tube (referred to as the above-described Braun tube: CRT)  
of a computer, etc., as an example of OA equipment, it must  
be easy to see the display screen in order to prevent visual  
fatigue, as well as prevent deposition of dust and electric  
20 shock induced by the electrostatic charge on the CRT screen,  
etc. Furthermore, in addition to these requirements, etc.,  
there has recently been concern over the detrimental effects  
of low-frequency electromagnetic waves generated by CRTs  
on the human body and there is a demand for CRTs with which

there is no leakage to the outside of such electromagnetic waves.

As measures for such prevention of electrostatic charging or prevention of leakage of electromagnetic waves (electric field shielding), there have been adopted conventionally a method of coating the front panel surface of a CRT, etc., with a transparent conductive layer, and other methods.

Additionally, it is desired that surface resistance of these transparent conductive layers be in the order of  $10^7$  to  $10^{11} \Omega / \square$  (ohm per square) for prevention of electrostatic charging, and be at least no more than  $10^6 \Omega / \square$  for prevention of leakage of electromagnetic waves, preferably no more than  $5 \times 10^3 \Omega / \square$ , and more preferably no more than  $10^3 \Omega / \square$ .

Therefore, several suggestions have been made thus far for meeting these requirements, but of these, the method wherein a coating liquid for forming a transparent conductive layer prepared by dispersing conductive microparticles in a solvent is applied to the front glass of a CRT and dried, and a coating liquid for forming a transparent coat layer comprising as its main component an inorganic binder such as silica sol, and then baked at a temperature of the order of  $200^\circ\text{C}$  is known as a method with

which low cost and low surface resistance can be realized.

This method that uses a coating liquid for forming a transparent conductive layer is very simple when compared to other methods of forming transparent conductive layers, such as vacuum evaporation and sputtering, has a low production cost, and is a very useful method.

Moreover, for the above-mentioned transparent microparticles, there are used transparent conductive oxide microparticles such as tin antimony oxide (ATO) or indium tin oxide or metal microparticles, etc. For example, in the case of application of ATO, because surface resistance of the film that is obtained is in the order of  $10^7$  to  $10^{10} \Omega/\square$ , the film is used for preventing electrostatic charging.

In addition, although a coating liquid for forming a transparent conductive layer employing indium tin oxide is used for shielding an electric field, surface resistance of the film that is obtained is in the order of  $10^4$  to  $10^6 \Omega/\square$ , which is insufficient to block leakage of an electric field, therefore a corrective circuit for canceling the electric field is needed.

On the other hand, when compared to coating liquids that use ITO, a film with somewhat lower transmittance, but also low resistance of  $10^2$  to  $10^3 \Omega/\square$ , is obtained with coating liquids for forming transparent conductive layers

that use metal ~~ma~~icroparticles for the above-mentioned  
conductive microparticles so that shielding an electric  
field can be performed without use of the above-mentioned  
corrective circuit.

5           Moreover, the metal microparticles that are used in  
the above-mentioned coating liquid for forming the  
above-mentioned transparent conductive layer are limited  
to noble metals, such as silver, gold, platinum, rhodium,  
palladium, etc., that rarely oxidize in air, as shown in  
10 Japanese Patent Applications Laid-Open No. H 8-77832 and  
Laid-Open No. H 9-55175. This is because if microparticles  
of a metal other than a noble metal, such as iron, nickel,  
cobalt, etc., are used, an oxide film is invariably formed  
on the surface of such metal microparticles in an air  
15 atmosphere and good conductivity cannot be obtained as a  
transparent conductive layer.

          Moreover, on the other hand, in order to make the  
display screen easy to see, anti-glare treatment is  
performed on the face panel surface to prevent reflection  
20 on the screen. This antiglare treatment is performed by the  
method whereby fine irregularities are made in the surface  
in order to increase diffused reflection at the surface,  
but it cannot be said that this method is a very desirable  
method because when used, resolution decreases and picture

quality drops.

Consequently, it is preferred that antiglare treatment be performed by the interference method whereby the refractive index and film thickness of the transparent  
5 film be controlled so that there is destructive interference of the incident light by the reflected light.

A two-layered film structure wherein optical film thickness of film with a high refractive index and film with a low refractive index has been set at  $1/4 \lambda$  and  $1/4 \lambda$ , or  
10  $1/2 \lambda$  and  $1/4 \lambda$ , respectively, is usually used in order to obtain this type of low-reflection effect of the interference method, and film consisting of the above-mentioned indium tin oxide (ITO) microparticles is also used as this type of film with a high refractive index.

15 Furthermore, of the optical constant ( $n-ik$ ,  $n$ : refractive index,  $i^2 = -1$ ,  $k$ : extinction coefficient) of metals, the value of  $n$  is small, but the value of  $k$  is very large when compared to ITO and therefore, even if a transparent conductive layer consisting of metal  
20 microparticles is used, the same anti-reflection activity induced by interference of light as seen with ITO is obtained with the two-layered film structure.

Moreover, in recent years, in addition to the properties such as the above-mentioned good conductivity,

low reflectance, etc., this type of transparent conductive layered structure is requested to have the property of improving the contrast of images by adjusting the transmittance to the predetermined range (40 to 75%) lower than 100% in order to make the display screen easier to see. In this case, the mixing of color pigment microparticles, etc., into the above-mentioned coating liquid for forming a transparent conductive layer also has been performed.

In addition to this, as treatment for water resistance, brine resistance or anti-smudge of these transparent conductive layers, several attempts to make the layers water-repellent have been carried out recently.

Such a transparent conductive layered structure having a transparent two-layered film being composed of a transparent conductive layer and a transparent coat layer is produced, as mentioned above, by applying a coating liquid for forming a transparent conductive layer on a transparent substrate, and drying, and applying a coating liquid for a transparent coat layer as its main components silica sol, etc., and then conducting a heat treatment at a temperature of the order of 200°C.

Moreover, because the above-mentioned transparent coat layer comprises as its main component silicon oxide, the layer is formed as a film of relatively high strength

by heat treatment at a temperature of the order of 200°C.

However, depending on the producers or makers of CRTs, there are cases where the above-mentioned heat treatment temperature is performed only under the condition of the order of 160°C because of the limitation of facility aspect, etc., so that the strength of some transparent coating films may be insufficient due to the low temperature heating.

Similarly, for a coating liquid for forming a transparent conductive layer using the above-mentioned noble metal microparticles, the coating strength of some transparent two-layered films that are obtained is insufficient. It is considered that this is because when compared to conductive oxide microparticles such as ITO, etc., noble metal microparticles are chemically inert, and thus the binding between noble metal microparticles and an inorganic binder matrix is not so strong, and therefore the coating strength of the transparent two-layered films decreases.

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#### SUMMARY OF THE INVENTION

The present invention focuses on such problems, its object being to present a transparent conductive layered structure having the functions of preventing electrostatic



charging or shielding an electric field, and preventing reflection, the two-layered film of which has an excellent scratch strength (namely coating strength), and with which a reduction in production cost is expected and a method of  
5 producing the same, and a transparent coat layer forming coating liquid used in the method of producing the same, and a display device to which the transparent conductive layered structure is applied.

That is, the invention of Claim 1 resides in a  
10 transparent conductive layered structure, comprising a transparent substrate and a transparent two-layered film being composed of a transparent conductive layer and a transparent coat layer being formed in succession on the transparent substrate.

15 wherein the transparent conductive layer comprises, as its main components, conductive microparticles having a mean particle diameter of 1 to 100 nm and a binder matrix of silicon oxide, and wherein the transparent coat layer comprises, as its main component, a binder matrix of silicon  
20 oxide including one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms.

The invention of Claim 2 resides in a transparent conductive layered structure according to Claim 1, wherein the conductive microparticles are transparent conductive

oxide microparticles or/and noble metal microparticles.

The invention of Claim 3 resides in a transparent  
conductive layered structure according to Claim 2, wherein  
the transparent conductive oxide microparticles are indium  
5 tin oxide or tin antimony oxide.

The invention of Claim 4 resides in a transparent  
conductive layered structure according to Claim 2, wherein  
the noble metal microparticles are any of: noble metal  
microparticles selected from gold, silver, platinum,  
10 palladium, rhodium, and ruthenium; alloy microparticles of  
these noble metals; or noble metal-coated silver  
microparticles the surface of which is coated with these  
noble metals other than silver.

The invention of Claim 5 resides in a transparent  
15 conductive layered structure according to Claim 4, wherein  
the noble metal-coated silver microparticles are silver  
microparticles coated with gold or platinum only or a  
composite of gold and platinum.

Next, the invention of Claims 6 through 11 relates  
20 to the invention defining a method of producing the  
transparent conductive layered structure.

The invention of Claim 6 resides in a method of  
producing the transparent conductive layered structure  
according to Claim 1, comprising the steps of:

applying on a transparent substrate a transparent  
conductive layer forming coating liquid comprising, as its  
main components, a solvent and conductive microparticles  
having a mean particle diameter of 1 to 100 nm dispersed  
5 in the solvent;

then applying a transparent coat layer forming  
coating liquid comprising, as its main component, an  
inorganic binder composed of silica sol including an alkyl  
group containing compound having one or more types of alkyl  
10 groups selected from long chain alkyl groups containing 7  
to 30 carbon atoms; and

performing heat treatment.

The invention of Claim 7 resides in a method of  
producing the transparent conductive layered structure,  
15 according to Claim 6, wherein the conductive microparticles  
are transparent conductive oxide microparticles or/and  
noble metal microparticles.

The invention of Claim 8 resides in a method of  
producing the transparent conductive layered structure,  
20 according to Claim 7, wherein the transparent conductive  
oxide microparticles are indium tin oxide or tin antimony  
oxide.

The invention of Claim 9 resides in a method of  
producing the transparent conductive layered structure,

according to Claim 7, wherein the noble metal microparticles are any of: noble metal microparticles selected from gold, silver, platinum, palladium, rhodium, and ruthenium; alloy microparticles of these noble metals; or noble metal-coated silver microparticles coated with these noble metals other than silver.

The invention of Claim 10 resides in a method of producing the transparent conductive layered structure, according to Claim 9, wherein the noble metal-coated silver microparticles are silver microparticles coated with gold or platinum only or a composite of gold and platinum.

The invention of Claim 11 resides in a method of producing the transparent conductive layered structure, according to any of Claims 6 through 10, wherein the transparent conductive forming coating liquid includes an inorganic binder comprising, as its main component, silica sol.

Further, the invention of Claim 12 or 13 relates to the invention defining a transparent coat layer forming coating liquid used for the above-mentioned method of producing the transparent conductive layered structure.

That is, the invention of Claim 12 resides in a transparent coat layer forming coating liquid used for the method of producing the transparent conductive layered

structure according to Claim 6, comprising, as its component:

a solvent, an inorganic binder composed of silica sol, and an alkyl group containing compound having one or  
5 more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms;

wherein a mixture ratio of the inorganic binder and the alkyl group containing compound is from 0.1 to 20 parts by weight of the alkyl group containing compound to 100 parts  
10 by weight of the inorganic binder.

The invention of Claim 13 resides in transparent coat layer forming coating liquid according to Claim 12, wherein the alkyl group containing compound is a compound including, in a molecule, a hydrolyzable alkoxysilyl group or a  
15 functional group generated by hydrolysis of the hydrolyzable alkoxysilyl group.

Moreover, the invention of Claim 14 resides in a display device comprising a main apparatus body and a front panel disposed in front thereof,

20 wherein the transparent conductive layered structure according to any of Claims 1 through 5 is incorporated as the front panel with the side of the transparent two-layered film thereof being disposed outside.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the present invention  
5 will now be described in detail.

In a transparent conductive layered structure comprising a transparent two-layered film being composed of a transparent conductive layer and a transparent coat layer being formed in succession on a transparent substrate,  
10 the present invention is aimed at improving a coating strength, particularly scratch strength of the above-mentioned transparent two-layered film. That is, when observed microscopically, on the surface of the above-mentioned transparent two-layered film, there exist fine  
15 irregularities, which are one of the factors decreasing the scratch strength.

Here, a scratch strength is literally an abrasion resistant strength, which can be evaluated, for example, by a steel wool test, a pencil strength test, a diamond  
20 scratch test, etc.

In addition, the present invention was completed based on the discovery that with regard to the above-mentioned transparent coat layer, when this is made of a binder matrix of silicon oxide including a long chain alkyl

group, the scratch strength of the transparent two-layered film can be remarkably improved. That is, a long chain alkyl group has such high hydrophobicity that when a transparent coat layer forming coating liquid is applied and dried, portions thereof are oriented on the outer surface of a transparent coat layer comprising as its main component silicon oxide, and therefore the action of the oriented long chain alkyl group can make lubricity of the coating higher. Moreover, it is considered that because the lubricity of the coating becomes higher, the scratch strength can be improved even if there exist fine irregularities on the surface of the transparent coat layer. Furthermore, the layer can also be repellent to water due to the above-mentioned orientation of the hydrophobic long chain alkyl group on the outer surface of the layer.

Here, the above-mentioned long chain alkyl groups should contain 7 to 30 carbon atoms (Claim 1). When carbon atoms are less than 7, there will be a small amount of orientation on the surface, and in addition, even if the long chain alkyl groups are oriented, lubrication action itself that the long chain alkyl groups have will be insufficient and the effect of improving the scratch strength will be small, which will be impractical. In addition, when carbon atoms are more than 30, it might cause

a problem in solubility of the alkyl group containing compound having the long chain alkyl groups to the transparent coat layer forming coating liquid or in coatability of the transparent coat layer forming coating liquid, which will not be preferred.

Furthermore, when the above-mentioned alkyl group containing compound has, in a molecule, a hydrolyzable alkoxysilyl group or a functional group generated by hydrolysis of the hydrolyzable alkoxysilyl group [ $-\text{SiR}^1_x(\text{OR}^2)_y$ ,  $\text{R}^1$  and  $\text{R}^2$ :  $\text{C}_n\text{H}_{2n-1}$ ,  $n=0$  to  $4$ ,  $X=0$  to  $2$ ,  $Y=3-X$ ], the above-mentioned hydrolyzed alkoxysilyl group will be strongly bound to silica, and therefore the binding between the long chain alkyl group portions oriented on the surface of the transparent coat layer and the binder matrix of silicon oxide will be strong.

For example, in the following Comparative Example 1, pencil hardness of the transparent two-layered film comprising gold-silver binary system microparticles and a silicon oxide binder matrix is 6H, on the other hand, in the case of the transparent two-layered film in Example 1 employing the binder matrix of silicon oxide including an n-decyl group ( $\text{C}_{10}\text{H}_{21}-$ ) and a trimethylsilyl group [ $-\text{Si}(\text{OCH}_3)_3$ ] (actually, a group [ $-\text{Si}(\text{OH})_3$ ] hydrolyzed in the transparent coat layer forming coating liquid occurs), the



pencil hardness of 8H results, which represents an excellent scratch strength.

Here, in a transparent coat layer forming coating liquid, a mixture ratio of an alkyl group containing compound having one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms is preferably from 0.1 to 20 parts by weight of the alkyl group containing compound to 100 parts by weight of the inorganic binder ( $\text{SiO}_2$ ) in a silica sol, and more preferably from 0.3 to 10 parts by weight. When the above-mentioned alkyl group containing compound is less than 0.1 parts by weight, the effect of the above-mentioned long chain alkyl group will be insufficient, and when it is more than 20 parts by weight, the strength of the binder matrix itself will decrease, which will be unpreferred.

Furthermore, the above-mentioned conductive microparticles of the present invention should have a mean particle diameter of 1 to 100 nm (Claim 1). When it is less than 1 nm, it will be difficult to produce these microparticles, and if mean particle diameter exceeds 100 nm, scattering of visible light ray on the formed transparent conductive layer will be so much enhanced that haze value of the film will be too high, which will be impractical.

In addition, the mean particle diameter as used here

means the mean particle diameter of microparticles observed under a transmission electron microscope (TEM).

Moreover, for the above-mentioned conductive microparticles included in the transparent conductive layer forming coating liquid of the present invention, transparent conductive oxide microparticles or/and noble metal microparticles is used (Claims 2 and 7), and for the above-mentioned transparent conductive oxide microparticles, indium tin oxide or tin antimony oxide can be used (Claims 3 and 8), and for the above-mentioned noble metal microparticles, any of: noble metal microparticles selected from gold, silver, platinum, palladium, rhodium, and ruthenium; alloy microparticles of these noble metals; or noble metal-coated silver microparticles the surface of which is coated with these noble metals other than silver can be used (Claims 4 and 9).

Here, when specific resistance of silver, gold, platinum, rhodium, palladium, ruthenium etc. is compared, the specific resistance of platinum, rhodium, palladium, and ruthenium is 10.6, 5.1, 10.8, and  $6.71 \mu \Omega \cdot \text{cm}$  respectively, which is higher than that of silver and gold being 1.62 and  $2.2 \mu \Omega \cdot \text{cm}$  respectively, and therefore use of silver microparticles or gold microparticles is considered to be advantageous in order to form a transparent

conductive layer having low surface resistance.

However, when silver microparticles are used, the application will be limited from the aspect of weather resistance wherein degradation by brine or sulfurization is vigorous. On the other hand, when gold microparticles are used, there will be no problem with the above-mentioned weather resistance, but when aspect of cost taken into consideration, the gold microparticles will not always be most preferable.

10 Accordingly, microparticles wherein on the surface of silver microparticles are coated noble metals other than silver, can be used. For example, the present inventors have already proposed a transparent conductive layer forming coating liquid using noble metal-coated silver  
15 microparticles having a mean particle diameter of 1 to 100 nm coated with gold or platinum only or a composite of gold and platinum (Claims 5 and 10) and the method of producing the same (refer to Japanese Patent Application Laid-Open No. H 11-228872 and the specification of Japanese Patent  
20 Application No. H 11-366343).

In addition, for the above-mentioned noble metal-coated silver microparticles, specific resistance of platinum is somewhat higher than that of silver and gold, as previously mentioned, and therefore, as surface

resistance of a transparent conductive film, Ag-Au system is more preferable than Ag-Pt system and Ag-Au-Pt system. However, since gold or platinum only or a composite of gold and platinum is used as coating layer on the surface of the above-mentioned silver microparticles, the good electrical conductivity of the silver is not lost to such an extent that it falls below the level needed for practical application, even if the above-mentioned Ag-Pt system or Ag-Au-Pt system is used.

10           Next, for the above-mentioned noble metal-coated silver microparticles, the coating amount of gold or platinum only or a composite of gold and platinum is preferably set within a range no less than 5 parts by weight up to 1900 parts by weight to 100 parts by weight of silver, and more preferably set within a range no less than 100 parts by weight up to 900 parts by weight. When the coating amount of gold or platinum only or a composite of gold and platinum is less than 5 parts by weight, deterioration of the film by the influence of ultraviolet rays, etc., tends to occur, and therefore, no protective effect of the coating will be observed, while when it exceeds 1900 parts by weight, productivity of the noble metal-coated silver microparticles will be down as well as there will be prohibition in terms of cost.

Furthermore, when gold or platinum only or a composite of gold and platinum is coated on the surface of silver microparticles, silver within the noble metal-coated silver microparticles will be protected by the gold or platinum only or the composite of gold and platinum, and therefore, weather resistance, chemical resistance, ultraviolet ray resistance, etc., will be markedly improved.

Next, a transparent conductive layer forming coating liquid employing, as conductive microparticles, noble metal microparticles and transparent conductive oxide microparticles used in the present invention can be produced, for example, by the following methods, respectively.

That is, for a transparent conductive layer forming coating liquid employing noble metal microparticles, a colloidal dispersion of silver microparticles is prepared by a conventional method (for instance, the Carey-Lea method, Am. J. Sci., 37, 47(1889), Am. J. Sci., 38(1889)), and then the silver microparticles are coated with gold by adding to this dispersion a reducing agent such as hydrazine, etc., and an aurate solution are added to this dispersion. A dispersion of noble metal-coated silver microparticles can be obtained in this way. Furthermore, a trace of dispersant may be added to either or both of a colloidal dispersion

of silver microparticles and an aurate solution during the gold coating process as needed.

Then, it is preferable to lower the electrolyte concentration in the dispersion using a method, such as dialysis, electrodialysis, ion exchange, ultrafiltration, etc. This is because colloids generally aggregate with electrolytes when the electrolyte concentration is high. This phenomenon is known as the Schulze-Hardy rule.

Finally, a coating liquid comprising noble metal-coated silver microparticles is prepared by accomplishing an adjustment of the components (microparticle content, water content, etc.), etc. by concentration of the colloidal dispersion of noble metal-coated silver microparticles, and addition of an organic solvent, etc.

Moreover, for a transparent conductive layer forming coating liquid employing transparent conductive oxide microparticles, transparent conductive oxide microparticles such as indium tin oxide (ITO) microparticles, antimony tin oxide (ATO) microparticles, etc., and a dispersant are added to a solvent, and then a dispersion of conductive oxide microparticles is obtained by dispersion treatment using a paint shaker, a bead mill, ultrasonic wave, etc. A transparent conductive layer

forming coating liquid which contains transparent  
conductive oxide microparticles can be prepared by  
accomplishing an adjustment of the components  
(microparticle content, etc.), etc., by addition of an  
5 organic solvent, etc.

By using the transparent conductive layer forming  
coating liquid having conductive microparticles such as  
noble metal microparticles, transparent conductive oxide  
microparticles, etc., as prepared in the above-mentioned  
10 manner, the following method can be used to form the  
above-mentioned transparent two-layered film on a  
transparent substrate.

That is, a transparent conductive layer forming  
coating liquid which comprises as its main components a  
15 solvent and conductive microparticles having a mean  
particle diameter of 1 to 100 nm dispersed in the solvent  
is applied by any method, such as spray coating, spin coating,  
wire bar coating, doctor blade coating, etc., to a  
transparent substrate, such as a glass substrate, a plastic  
20 substrate, etc., and when necessary, after drying,  
overcoating with a transparent coat layer forming coating  
liquid which comprises as its main component silica sol  
including an alkyl group containing compound having one or  
more types of alkyl groups selected from long chain alkyl

groups containing 7 to 30 carbon atoms is performed by the above-mentioned method.

Next, after overcoating, heat treatment is performed at a temperature of, for example, the order of 50 to 250°C, and the transparent coat layer that was overcoated is cured to form the above-mentioned two-layered film (Claim 6).

Improvement of conductivity, improvement of a coating strength, and even further improvement of weather resistance are simultaneously realized here when the transparent coat layer forming coating liquid which comprises as its main component silica sol including the above-mentioned alkyl group containing compound is overcoated by the above-mentioned methods because the silica sol liquid that has been overcoated (this silica sol liquid which includes an alkyl group containing compound having one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms becomes the binder matrix which comprises as its main component silicon oxide including the above-mentioned alkyl group with the above-mentioned heat treatment) soaks into the spaces in the transparent microparticles layer that was formed by pre-application of a transparent conductive layer forming coating liquid which comprises as its main component conductive microparticles and finally the binder matrix is



strongly bound to the substrate and the conductive microparticles.

In addition, the reflectance of the transparent two-layered film can be markedly reduced by the above-mentioned transparent two-layered structure film of a transparent coat layer and a transparent conductive layer wherein conductive microparticles are dispersed in a binder matrix.

Furthermore, the optical properties, such as reflectance, transmittance, etc., of the above-mentioned transparent two-layered film even when using a binder matrix of silicon oxide which does not include a long chain alkyl group are still excellent in a similar manner when using a binder matrix of silicon oxide which includes a long chain alkyl group. It is considered that this is because there is little change in optical constant of the binder matrix even when introducing a long chain alkyl group into the binder matrix of silicon oxide.

~~Here, as this silica sol including an alkyl group~~  
containing compound having one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms, there can be used a polymer obtained by adding water and acid catalyst to orthoalkyl silicate and alkyl group containing silicon compounds, such as n-

octyltrimethoxysilane,      n-octyltriethoxysilane,      n-  
decyltrimethoxysilane,      n-hexadecyltrimethoxysilane,      n-  
octadecyltrimethoxysilane,      n-  
octadecylmethyldimethoxysilane,      n-

5      octadecyltriethoxysilane, etc., for hydrolysis and then  
promoting dehydropolycondensation, or a mixture obtained  
by adding the above-mentioned alkyl group containing  
silicon compounds to a polymer (silica sol) obtained by  
adding water and acid catalyst to a commercial alkyl silicate  
10      solution already hydrolyzed and promoted through  
polymerization up to a tetramer or pentamer, for further  
hydration and then promoting dehydropolycondensation, etc.

When being added to silica sol, the alkoxysilyl group  
portions in the above-mentioned alkyl group containing  
15      silicon compounds are hydrolyzed within several hours to  
several days. The above-mentioned transparent coat layer  
forming coating liquid is preferably used after this  
hydrolysis. Furthermore, when dehydropolycondensation is  
promoted, the solution viscosity rises until it finally  
20      solidifies and therefore, the degree of  
dehydropolycondensation is adjusted to the upper viscosity  
limit with which application to a transparent substrate,  
such as a glass substrate, plastic substrate, etc., is  
possible or lower. There are no particular specifications

for the degree of dehydropolycondensation as long as it is at the level of the this limit or lower.

Moreover, the alkyl silicate hydrolyzed polymer including the above-mentioned long chain alkyl group forms a cured silicate film (film comprising as its main component a binder matrix of silicon oxide including one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms), with the dehydropolycondensation reaction all but completed, during heating and baking of the transparent two-layered film.

Furthermore, the refractive index of the transparent coat layer can be adjusted to change the reflectance of the transparent two-layered film by adding magnesium fluoride microparticles, alumina sol, titania sol, zirconia sol, etc., to the above-mentioned silica sol including an alkyl group containing compound having one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms.

In addition, in the process for forming the above-mentioned transparent conductive layer, the above-mentioned transparent conductive layer forming coating liquid made by mixing a silica sol liquid as the inorganic binder component that makes up the binder matrix in addition to the solvent and the conductive microparticles

having a mean particle diameter of 1 to 100 nm dispersed in this solvent may be used (Claim 11). In this case also, the same above-mentioned transparent two-layered film is obtained by applying the transparent conductive layer forming coating liquid comprising a silica sol liquid and when necessary, after drying, overcoating a transparent coat layer forming coating liquid by the above-mentioned method.

Furthermore, in the process for forming the above-mentioned transparent conductive layer, the above-mentioned transparent conductive layer forming coating liquid made by mixing a polymer resin in addition to the solvent and the conductive microparticles having a mean particle diameter of 1 to 100 nm dispersed in this solvent may be used. When a polymer resin is added, conductive microparticles in the transparent conductive layer forming coating liquid can be stabilized and longer pot life of the transparent conductive layer forming coating liquid can be obtained. However, since strength and weather resistance of the transparent conductive film that is obtained tend to be somewhat lower, attention should be given when employing the polymer resin.

Moreover, in order to make the display screen easier to see by adjusting the transmittance of the above-mentioned

transparent two-lay red film to the pred termined range (40 to 75%) lower than 100%, color pigment microparticles, etc., may be mixed into the above-mentioned transparent conductive layer forming coating liquid. For example, one  
5 or more types of microparticles selected from carbon, titanium black, titanium nitride, composite oxide pigment, cobalt violet, molybdenum orange, ultramarine, Prussian blue, quinacridone pigment, anthraquinone pigment, perylene pigment, isoindolinone pigment, azo pigment, and  
10 phthalocyanine pigment, etc., can be used as the above-mentioned color pigment microparticles.

As described above, a transparent conductive layered structure according to the present invention, as compared to the conventional ones, has an excellent coating strength  
15 and weather resistance. Moreover it has an excellent anti-reflection activity and transmission profile, and also has antistatic or electric field-shielding activity. Thus, it can be used, for example, as a front panel, etc., of display devices, such as CRTs, plasma display panels (PDPs),  
20 vacuum fluorescent displays (VFDs), field emission displays (FEDs), electroluminescence displays (ELDs), liquid crystal displays (LCDs), etc.

#### [Examples]

Examples of the present invention will now be

explained in the concrete, but the present invention is not limited to these examples. Moreover, the "%" in this text are "wt%" with the exception of the (%) used for transmittance, reflectance and haze value, and the "parts" are "parts by weight."

[Example 1]

A colloidal dispersion of silver microparticles was prepared by the above-mentioned Carey-Lea method.

In the concrete, after adding a mixed solution of 39 g aqueous 23% iron sulfate (II) solution and 48 g aqueous 37.5% sodium citrate solution to 33 g aqueous 9% silver nitrate solution, the precipitate was filtered and washed. Then pure water was added to prepare a colloidal dispersion of silver microparticles (Ag: 0.15%).

Next, a mixed solution of 8.0 g aqueous 1% hydrazine monohydrate ( $N_2H_4 \cdot H_2O$ ), 480 g aqueous potassium aurate [ $KAu(OH)_4$ ] solution (Au: 0.075%) and 0.2 g aqueous 1% polymer dispersant solution was added while agitating to 60 g of this colloidal dispersion of silver microparticles to obtain a colloidal dispersion of noble metal-coated silver microparticles.

Once desalting of this colloidal dispersion of noble metal-coated silver microparticles was performed with an ion-exchange resin (Diaion SK1B, SA20AP; brand names of

Mitsubishi Chemical Corporation), ultrafiltration was performed, and to the concentrated dispersion of the noble metal-coated silver microparticles which was obtained, ethanol (EA), propylene glycol monomethyl ether (PGM), diacetone alcohol (DAA) and formamide (FA) were added to obtain a transparent conductive layer forming coating liquid that contains noble metal-coated silver microparticles (Ag: 0.08%, Au: 0.32%, water: 10.7%, EA: 53.8%, PGM: 25%, DAA: 10%, FA: 0.1%).

As a result of observing this obtained transparent conductive layer forming coating liquid under a transmission electron microscope, the mean particle diameter of the noble metal-coated silver microparticles was 7.5 nm.

Next, this transparent conductive layer forming coating liquid was spin coated (150 rpm, 60 seconds) onto a glass substrate (soda lime glass with a thickness of 3 mm) that had been heated to 40°C and then a transparent coat layer forming coating liquid was spin coated (150 rpm, 60 seconds) and the product was further cured for 20 minutes at 180°C to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising noble metal-coated silver microparticles and a binder matrix of silicon oxide and a transparent coat layer

c nsisting of silicate film comprising as its main component silicon oxide including a long chain alkyl group, that is, the transparent conductive layered structure of Example 1.

Here, the above-mentioned transparent coat layer  
5 forming coating liquid was obtained as follows.

The silica sol liquid was obtained by preparing, first, a substance with an  $\text{SiO}_2$  (silicon oxide) solid content of 10% and a weight-average molecular weight of 1,190 using 19.6 parts Methyl Silicate 51 (Colcoat Co., Ltd., brand name),  
10 57.8 parts ethanol, 7.9 parts aqueous 1% nitric acid solution, and 14.7 parts pure water and then diluting this with a mixture of isopropyl alcohol (IPA) and n-butanol (NBA) (IPA/NBA = 3/1) to a final  $\text{SiO}_2$  solid content of 0.8%. To this silica sol liquid, n-decyltrimethoxysilane  
15  $[\text{C}_{10}\text{H}_{21}\text{Si}(\text{OCH}_3)_3]$  was added to obtain a transparent coat layer forming coating liquid which includes 0.3 parts by weight of n-decyltrimethoxysilane  $[\text{C}_{10}\text{H}_{21}\text{Si}(\text{OCH}_3)_3]$  to 100 parts by weight of the inorganic binder ( $\text{SiO}_2$ ) in the silica sol liquid.

20 In addition, film properties of the transparent two-layered film formed on the glass substrate (surface resistance, visible light ray transmittance, standard deviation of transmittance, haze value, bottom reflectance/bottom wavelength, and pencil hardness) are



shown in Table 1 below.

Furthermore, the above-mentioned bottom reflectance means minimum reflectance in the reflection profile of the transparent conductive layered structure, and the bottom wavelength means the wavelength when reflectance is at its minimum.

Moreover, the above-mentioned pencil hardness is evaluated by observing abrasions occurred when lines are drawn on the surface of the transparent two-layered film with pencils having a hardness of H to 9H under a load of 1 kg.

Furthermore, transmittance of the transparent two-layered film only without the transparent substrate (glass substrate) at each wavelength in 5 nm intervals of the visible light ray wavelength region (380 to 780 nm) in Table 1 is found as follows.: That is,

Transmittance of transparent two-layered film only without transparent substrate (%)

$$= \frac{[(\text{transmittance determined inclusive of transparent substrate}) / (\text{transmittance of transparent substrate})] \times 100.}{20}$$

Unless otherwise noted, here the value of transmittance of the transparent two-layered film only without the transparent substrate is used as the

transmittance in the present specification.

Moreover, surface resistance of the transparent two-layered film was determined using the surface resistance meter (Loresta AP MCP-T400) of Mitsubishi Chemical Corporation.

Furthermore, the above-mentioned haze value and visible light ray transmittance were determined using a haze meter (HR-200) made by Murakami Color Research Laboratory, and further the above-mentioned reflectance and standard deviation of transmittance were determined using spectrophotometer (U-4000) made by Hitachi Ltd. In addition, particle diameter of the noble metal-coated silver microparticles that are conductive microparticles was evaluated under a transmission electron microscope made by JEOL Ltd.

[Example 2]

Other than the fact that n-decyltrimethoxysilane was added to obtain a transparent coat layer forming coating liquid as in Example 1 which includes 1.0 parts by weight of n-decyltrimethoxysilane to 100 parts by weight of the inorganic binder ( $\text{SiO}_2$ ) in the silica sol liquid, the same treatment as in Example 1 was performed to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising noble metal-

coated silver microparticles that are conductive microparticles and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide including  
5 a long chain alkyl group, that is, the transparent conductive layered structure of Example 2.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

10 [Example 3]

Other than the fact that n-decyltrimethoxysilane was added to obtain a transparent coat layer forming coating liquid as in Example 1 which includes 5.0 parts by weight of n-decyltrimethoxysilane to 100 parts by weight of the  
15 inorganic binder ( $\text{SiO}_2$ ) in the silica sol liquid, the same treatment as in Example 1 was performed to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising noble metal-coated silver microparticles that are conductive  
20 microparticles and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide including a long chain alkyl group, that is, the transparent conductive layered structure of Example 3.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

[Example 4]

5 Other than the fact that 0.01 parts by weight of an acrylic system polymer resin was added to 100 parts by weight of a transparent conductive layer forming coating liquid as in Example 2, the same treatment as in Example 2 was performed to obtain a glass substrate with a transparent  
10 two-layered film composed of a transparent conductive layer comprising noble metal-coated silver microparticles that are conductive microparticles, a polymer resin and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component  
15 silicon oxide including a long chain alkyl group, that is, the transparent conductive layered structure of Example 4.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

20 [Example 5]

Other than the fact that n-octyltrimethoxysilane  $[C_8H_{17}Si(OCH_3)_3]$  was added to obtain a transparent coat layer forming coating liquid as in Example 1 which includes 0.5 parts by weight of n-octyltrimethoxysilane to 100 parts by

w ight of the inorganic binder ( $\text{SiO}_2$ ) in the silica sol liquid,  
the same treatment as in Example 1 was performed to obtain  
a glass substrate with a transparent two-layered film  
composed of a transparent conductive layer comprising noble  
5 metal-coated silver microparticles that are conductive  
microparticles and a binder matrix of silicon oxide and a  
transparent coat layer consisting of silicate film  
comprising as its main component silicon oxide including  
a long chain alkyl group, that is, the transparent conductive  
10 layered structure of Example 5.

The above-mentioned film properties of the  
transparent two-layered film formed on the glass substrate  
are shown in Table 1 below.

[Example 6]

15 Other than the fact that n-octyltrimethoxysilane  
was added to obtain a transparent coat layer forming coating  
liquid as in Example 1 which includes 1.0 parts by weight  
of n-octyltrimethoxysilane to 100 parts by weight of the  
inorganic binder ( $\text{SiO}_2$ ) in the silica sol liquid, the same  
20 treatment as in Example 1 was performed to obtain a glass  
substrate with a transparent two-layered film composed of  
a transparent conductive layer comprising noble metal-  
coated silver microparticles that are conductive  
microparticles and a binder matrix of silicon oxide and a

transparent coat layer consisting of silicate film comprising as its main component silicon oxide including a long chain alkyl group, that is, the transparent conductive layered structure of Example 6.

5           The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

[Example 7]

Other than the fact that n-  
10 hexadecyltrimethoxysilane [ $C_{16}H_{33}Si(OCH_3)_3$ ] was added to obtain a transparent coat layer forming coating liquid as in Example 1 which includes 1.0 parts by weight of n-hexadecyltrimethoxysilane to 100 parts by weight of the inorganic binder ( $SiO_2$ ) in the silica sol liquid, the same  
15 treatment as in Example 1 was performed to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising noble metal-coated silver microparticles that are conductive microparticles and a binder matrix of silicon oxide and a  
20 transparent coat layer consisting of silicate film comprising as its main component silicon oxide including a long chain alkyl group, that is, the transparent conductive layered structure of Example 7.

The above-mentioned film properties of the

transparent two-layered film formed on the glass substrate are shown in Table 1 below.

[Example 8]

After mixing 20.0 g of ITO microparticles (SUFP-HX, made by Sumitomo Metal Mining Co., Ltd.) having a mean particle diameter of 30 nm and 1.5 g of a dispersant, with 78.5 g of ethanol, dispersion treatment using a paint shaker with zirconia beads was performed to obtain a dispersion of ITO microparticles having a dispersion particle diameter of 105 nm.

Ethanol (EA), propylene glycol monomethyl ether (PGM) and diacetone alcohol (DAA) were added to this dispersion of ITO microparticles to obtain a transparent conductive layer forming coating liquid that contains ITO microparticles (ITO: 2.0%, EA: 82.8%, PGM: 10.0%, DAA: 5.0%).

Then, other than the fact that the above-mentioned transparent conductive layer forming coating liquid that contains ITO microparticles was used as a transparent conductive layer forming coating liquid as in Example 2, the same treatment as in Example 2 was performed to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising ITO microparticles that are conductive microparticles and a

binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide including a long chain alkyl group, that is, the transparent conductive layered structure of Example 8.

5           The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

[Comparative Example 1]

Other than the fact that a silica sol liquid without  
10 addition of a long chain alkyl group containing silicon compound (n-decyltrimethoxysilane) was used as a transparent coat layer forming coating liquid as in Example 1, the same treatment as in Example 1 was performed to obtain a glass substrate with a transparent two-layered film  
15 composed of a transparent conductive layer comprising noble metal-coated silver microparticles that are conductive microparticles and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide, that is,  
20 the transparent conductive layered structure of Comparative Example 1.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.



[Comparativ Example 2]

Other than the fact that a silica sol liquid without addition of a long chain alkyl group containing silicon compound (n-decyltrimethoxysilane) was used as a transparent coat layer forming coating liquid as in Example 4, the same treatment as in Example 4 was performed to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising noble metal-coated silver microparticles that are conductive microparticles, a polymer resin, and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide, that is, the transparent conductive layered structure of Comparative Example 2.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

[Comparative Example 3]

Other than the fact that n-hexyltrimethoxysilane [ $C_6H_{13}Si(OCH_3)_3$ ] was added to obtain a transparent coat layer forming coating liquid as in Example 1 which includes 1.0 parts by weight of n-hexyltrimethoxysilane to 100 parts by weight of the inorganic binder ( $SiO_2$ ) in the silica sol liquid, the same treatment as in Example 1 was performed to obtain

a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising noble metal-coated silver microparticles that are conductive microparticles and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide including alkyl group, that is, the transparent conductive layered structure of Comparative Example 3.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1 below.

[Comparative Example 4]

Other than the fact that a silica sol liquid without addition of a long chain alkyl group containing silicon compound (n-decyltrimethoxysilane) was used as a transparent coat layer forming coating liquid as in Example 8, the same treatment as in Example 8 was performed to obtain a glass substrate with a transparent two-layered film composed of a transparent conductive layer comprising ITO microparticles that are conductive microparticles, and a binder matrix of silicon oxide and a transparent coat layer consisting of silicate film comprising as its main component silicon oxide, that is, the transparent conductive layered structure of Comparative Example 4.

The above-mentioned film properties of the transparent two-layered film formed on the glass substrate are shown in Table 1.

Table 1

	Type of micro-particles	Gold content	Transparent coat layer forming				Surface resistance ( $\Omega/\square$ )	Visible light ray transmittance (%)	Standard deviation of transmittance (Note 3)	Raze value (t)	Bottom reflectance (%) / bottom wavelength (nm)	Pencil hardness
			coating liquid		Mixture ratio (Note 2)							
			containing									
			Alkyl group compound	Alkoxyalkyl group (Note 1)								
Example 1	Ag-Au	80 wt%	$C_{10}H_{21}$ -	-Si(OR) <sub>3</sub>	0.3	195	80.5	1.42	0.1	0.04/570	8H	
Example 2	Ag-Au	80 wt%	$C_{10}H_{21}$ -	-Si(OR) <sub>3</sub>	1.0	192	80.1	1.46	0.1	0.09/575	8H	
Example 3	Ag-Au	80 wt%	$C_{10}H_{21}$ -	-Si(OR) <sub>3</sub>	5.0	203	80.9	1.50	0.1	0.12/575	8H	
Example 4	Ag-Au	80 wt%	$C_{10}H_{21}$ -	-Si(OR) <sub>3</sub>	1.0	210	80.3	1.51	0.1	0.18/565	8H	
Example 5	Ag-Au	80 wt%	$C_6H_{13}$ -	-Si(OR) <sub>3</sub>	0.5	189	79.9	1.53	0.1	0.03/570	8H	
Example 6	Ag-Au	80 wt%	$C_6H_{13}$ -	-Si(OR) <sub>3</sub>	1.0	197	80.5	1.45	0.1	0.08/580	8H	
Example 7	Ag-Au	80 wt%	$C_{10}H_{21}$ -	-Si(OR) <sub>3</sub>	1.0	223	81.3	1.40	0	0.22/560	8H	
Example 8	ITO	—	$C_{10}H_{21}$ -	-Si(OR) <sub>3</sub>	1.0	15600	100	—	0.1	0.83/595	9H	
Comparative Example 1	Ag-Au	80 wt%	None	-Si(OR) <sub>3</sub>	0	199	80.6	1.45	0.1	0.16/570	6H	
Comparative Example 2	Ag-Au	80 wt%	None	-Si(OR) <sub>3</sub>	0	213	80.8	1.52	0.1	0.17/565	3H	
Comparative Example 3	Ag-Au	80 wt%	$C_6H_{13}$ -	-Si(OR) <sub>3</sub>	1.0	193	80.1	1.47	0.1	0.06/565	6H	
Comparative Example 4	ITO	—	None	-Si(OR) <sub>3</sub>	0	15000	100	—	0.1	0.85/590	7H	

Note 1: R is methyl group

Note 2: Parts by weight of an alkyl group containing compound to 100 parts by weight of an inorganic binder (SiO<sub>2</sub>).

Note 3: Value in terms of the transmittance (%) of the transparent two-layered film only without the transparent substrate at each wavelength in 5 nm intervals in the visible light ray wavelength region (380 to 780 nm).

[Chemical Resistance Tests]

The transparent conductive layered structures of Example 1 through 7 and the transparent conductive layered structures of Comparative Examples 1 through 3 were immersed in 5% brine for 24 hours and surface resistance and film appearance of the transparent two-layered film on the transparent substrate (glass substrate) were investigated. However, no change was observed.

[Water-Repellency Examination of Films]

Water-repellency of the transparent two-layered films of Examples 1 through 8 and Comparative Examples 1, 2 and 4 was evaluated by observing the water-repellent extent of ethanol (actually a mixture of ethanol and water because ethanol absorbs moisture in the air), after applying and spreading ethanol on the two-layered films with a cloth which had been infiltrated with ethanol. It was observed that ethanol which had been spread thereon was rapidly repelled like beads, on the transparent two-layered films of Examples 1 through 8, while the above-mentioned repellance like beads was not observed on the films of Comparative Examples 1, 2 and 4.

[Evaluation]

(1) As is clear from the results shown in Table 1, the surface resistance ( $\Omega/\square$ ) and the visible light ray

transmittance of the transparent two-layered film according to Examples 1 through 7 show very excellent properties as similar to those values of the transparent two-layered film according to Comparative Examples 1 through 3. Moreover, 5 the similar results were observed in a comparison between Example 8 and Comparative Example 4.

Next, the pencil hardness of the transparent two-layered film according to Examples 1 through 7 is more excellent when compared to the values (of 3H to 6H) of the 10 transparent two-layered film according to Comparative Examples 1 through 3. Moreover, the similar results were observed in a comparison between Example 8 and Comparative Example 4.

That is, it is confirmed that the coating strength 15 of the transparent two-layered film is substantially improved due to the introduction of long chain alkyl groups containing 7 to 30 carbon atoms into the transparent coat layer in each Example.

(2) Additionally, from the results in the above- 20 mentioned chemical resistance tests, it is also confirmed that the transparent two-layered film according to Examples 1 through 7, even when long chain alkyl groups containing 7 to 30 carbon atoms are introduced into the transparent coat layer, has an excellent weather resistance as similar

to the values of the transparent two-layered film according to Comparative Examples 1 through 3.

(3) As is seen from the results of water-repellency examination of films, the transparent two-layered films of Examples 1 through 8 were rendered to be repellent to water so that the effect of preventing water from penetrating into the films can be expected.

According to the transparent conductive layered structure of the present invention as described in Claims 1 through 5, since a transparent coat layer that constitutes one layer of the transparent two-layered film comprises as its main component a binder matrix of silicon oxide including one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms, the transparent conductive layered structure of the present invention as described in Claims 1 through 5, when compared to the conventional transparent conductive layered structure, has an excellent coating strength (scratch strength) and also has good conductivity and weather resistance and an excellent anti-reflection activity.

Moreover, according to the method of producing the transparent conductive layered structure of the present invention as described in Claims 6 through 11, since the method comprises the steps of: applying on a transparent

substrate a transparent conductive layer forming coating liquid comprising, as its main components, a solvent and noble metal microparticles having a mean particle diameter of 1 to 100 nm dispersed in the solvent; then applying a  
5 transparent coat layer forming coating liquid comprising, as its main component, an inorganic binder composed of silica sol including an alkyl group containing compound having one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms; and performing heat  
10 treatment, the method has the advantage of producing the transparent conductive layered structure according to Claims 1 through 5 with low cost and usefully.

Furthermore, according to the transparent coat layer forming coating liquid of the present invention as described  
15 in Claims 12 and 13, since the coating liquid comprising, as its component: a solvent, an inorganic binder composed of silica sol, and an alkyl group containing compound having one or more types of alkyl groups selected from long chain alkyl groups containing 7 to 30 carbon atoms; wherein a  
20 mixture ratio of the inorganic binder and the alkyl group containing compound is set from 0.1 to 20 parts by weight of the alkyl group containing compound to 100 parts by weight of the inorganic binder, the coating liquid has the effect of being applied to the method of producing the transparent



conductive layered structure according to Claims 1 through  
5.

Additionally, according to the display device of the  
present invention as described in Claim 14, since the  
5 transparent conductive layered structure according to any  
of Claims 1 through 5 is incorporated as a front panel with  
the side of the transparent two-layered film thereof being  
disposed outside, surface reflection on the screen is  
prevented and the display device has high antistatic or  
10 electric field-shielding activity.